Kanban in software engineering: A systematic mapping study

Muhammad Ovais Ahmad, Denis Dennehy, Kieran Conboy, Markku Oivo

Abstract

Following a well-established track record of success in other domains such as manufacturing, Kanban is increasingly used to achieve continuous development and delivery of value in the software industry. However, while research on Kanban in software is growing, these articles are largely descriptive, and there is limited rigorous research on its application and with little cohesive building of cumulative knowledge. As a result, it is extremely difficult to determine the true value of Kanban in software engineering. This study investigates the scientific evidence to date regarding Kanban by conducting a systematic mapping of Kanban literature in software engineering between 2006 and 2016. The search strategy resulted in 382 studies, of which 23 were identified as primary papers relevant to this research. This study is unique as it compares the findings of these primary papers with insights from a review of 23 Kanban experience reports during the same period. This study makes four important contributions, (i) a state-of-the-art of Kanban research is provided, (ii) the reported benefits and challenges are identified in both the primary papers and experience reports, (iii) recommended practices from both the primary papers and experience reports are listed and (iv) opportunities for future Kanban research are identified.

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1. Introduction

Rooted in lean manufacturing, Kanban has been used across a range of industries, including aeronautics (Venables, 2005), healthcare (Kim et al., 2009), retail clothing (Tokatti, 2008), human resource (Wijewardena, 2011), and software development (Anderson, 2010). Kanban is a Japanese word meaning ‘card or signboard’ (Sugimori et al., 1977; Anderson, 2010), verbal instruction, a light, a flag, or even a hand signal and is based on a pull system (Kimura and Terada, 1981; Huang and Kusiak, 1996).

The Kanban method has been well received in software engineering, and there is strong anecdotal evidence to suggest that its use is becoming quite prevalent across the community (Anderson, 2013; Denhegy and Conboy, 2016; Nord et al., 2012; Petersen and Wohlin, 2011; Poppendieck and Cusumano, 2012; Power and Conboy, 2015). Annual ‘State of Agile’ reports show that the use of Kanban increased from 31% to 39% in 2015 and from 39% to 50% in 2016 (VersionOne, 2016, 2017).

Software engineering has been plagued by numerous problems such as (i) a lack of reliability, (ii) poor response to change, (iii) limited agility, and (iv) excessive costs (Anderson, 2010). Kanban is seen as a method to overcome these challenges, allowing teams to respond to dynamic market changes, increase quality, reduce waste, and improve predictability (Abrahamsson et al., 2009; Dybå and Dingsøyr, 2008; Nurdiani et al., 2016; Taibi et al., 2017).

Despite the popularity of Kanban in software engineering, this study identifies a number of shortcomings in the Kanban literature in this regard. Firstly, in comparison to manufacturing, where the concept of Kanban has been extensively studied, practiced and matured over time, Kanban in software engineering must operate in an environment that is complex, highly contextual, and socially embedded (Lyttinen and Rose, 2006). To date, research has not sufficiently addressed or addressed these characteristics (e.g. Anderson et al., 2011; Cocco et al., 2011; Concas et al., 2013). Second, the effectiveness of Kanban has largely been supported by anecdotal evidence and largely by consultancy organisations whose primary business is based on these purported benefits (e.g. Cutter, 2011; Hurtado, 2013; Kniberg and Skarin, 2010; Shalloway, 2010). Thirdly, the three published systematic literature reviews (SLR’s) related to Kanban have limitations (i.e. Al-baik and Miller, 2015; Ahmad et al., 2013; Corona and Pani, 2013) as shown in Table 1.

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The literature review conducted by Al-Baik and Miller (2015) cited twenty peer-reviewed and seventeen non-peer reviewed articles (i.e. Anderson, 2010; Ladas, 2009; Boeg, 2012; Terlecka, 2012; Kniberg and Skarin, 2010; Zhang, 2010). As the research rigor of these non-peer reviewed articles has not be established, they do not adequately contribute to the accumulative building of knowledge about Kanban. The literature review conducted by Corona and Pani (2013) focused on the features of Kanban products and not its actual use in the real-world context in which Kanban is intended to be used. The literature review conducted by Ahmad et al. (2013) and Al-Baik and Miller (2015) focused on Kanban use only in the context of software development and excluded some Kanban experience reports and empirical studies with no explanations. However, this mapping study includes all Kanban experience reports and empirical studies between 2006 and 2016, which includes the broader areas of the software engineering discipline, namely, software development, software maintenance, software product development, project and project management and software engineering education.

To address this gap in knowledge, the overarching goal of this study is to identify the state-of-the-art of Kanban in software engineering by conducting a systematic mapping study. Conducting a systematic mapping of Kanban in software engineering is important as it can be used to provide a valuable baseline to assist new research efforts (Kitchenham et al., 2010; Petersen et al., 2015). The aims of this systematic mapping study are to:

1. provide a state-of-the-art of Kanban research in software engineering
2. synthesis the claimed benefits and challenges of Kanban in software engineering
3. identify the opportunities for future Kanban research

The paper is structured as follows. Background to Kanban in manufacturing and software engineering is presented. Next, the process (e.g. planning, conducting, reporting) of systematic mapping is presented and limitations of the study are acknowledged. Then, the state-of-the-art of Kanban research is presented. The reported benefits and challenges of Kanban are also analysed and categorised. Followed by discussion and implications for research and practice highlighted. The paper ends with conclusions and directions for future research.

2. Background and related work

This section commences with the origins of Lean and Kanban in manufacturing and explains how these concepts are used together. The evolution of Lean and Kanban in software engineering is then discussed. Related work on Kanban in software engineering is also discussed.

2.1. Lean and Kanban in manufacturing

Lean, which can be traced back to the 1940s, historically focused on cost reduction (Ohno, 1988), “the elimination of waste” (Naylor et al., 1999; Ohno, 1988; Womack et al., 1990), and “doing more with less” (Towill and Christopher, 2002). Sugimori et al. (1977) published the first academic paper describing kanban and advocated three reasons for its use: (i) reduction in information processing cost, (ii) rapid and precise acquisition of facts, and (iii) limiting surplus capacity of preceding shops or stages. However, the concept of Lean has morphed over time with emphasis shifting from cost and waste to value maximisation (Conboy, 2009). Lean strives to deliver maximum value to the customer by reducing waste, controlling variability, maximizing the flow of information, focusing on the whole process, and not on local improvements (Anderson et al., 2011; Poppendieck, 2002). Lean is a mindset, a mental model of how the world works (Poppendieck and Poppendieck, 2003). Lean thinking is guided by five interlinked concepts (Wang et al., 2012):

1. Value: Value as defined by the end customer.
2. Value stream: A map that identifies every step in the process and categorises each step in terms of the value it adds.
3. Flow: Refers to the continuous flow of valuable work in the process.
4. Pull: Customer orders pull product, ensuring nothing is built before it is needed.
5. Perfection: Striving for perfection in the process by continuously identifying and removing waste.

Lean was part of the Toyota Production System (TPS) and is based on two concepts: (i) automation with a human touch and (ii) Just-In-Time (JIT) production (Womack et al., 1990; Ohno 1988). To implement JIT at Toyota, Taiichi Ohno developed Kanban which enabled Toyota to (i) work effectively under specific production and market conditions (Ohno, 1988), (ii) facilitate smooth operation of TPS (Becker and Szczepanek, 1998; Chai, 2008; Gross and McInnis, 2003; Liker, 2004), and (iii) promote and achieve continuous improvement (Hiranabe, 2008; Shingo, 1989).

The benefits of kanban in manufacturing include: (i) limiting work in progress (WIP), (ii) monitoring and controlling production process, (iii) visual scheduling, (iv) improving flow, (v) responsiveness to changes, (vi) facilitating high production, (vii) preventing overproduction, (viii) improving capacity utilisation, (ix) and re-

Table 1
Comparison of previous Kanban SLR’s.

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<td>Purpose</td>
<td>Provides insight into Lean and Kanban concepts, principles and techniques</td>
<td>Discusses tools available for Kanban boards in software development</td>
<td>Identifies the use of Kanban only in software development literature</td>
<td>Kanban in the field of software engineering (e.g. software development, software maintenance, software product, program and portfolio management, software engineering education)</td>
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<td>Sources of primary studies</td>
<td>Combination of grey and scientific literature</td>
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